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Applicant: KOYAMA et al

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Title: MOLD FOR CASTING AND METHOD OF SURFACE TREATMENT THEREOF

DECLARATION UNDER 37 CFR 1.132

I, Hiroaki KOYAMA, an Inventor of the above-identified application, hereby declare as follows:

1. I have been engaged for 22 years in the design, manufacture and testing of casting dies of the type disclosed and claimed in the above identified application, and I am employed by Honda Engineering Co., Ltd., a corporation, whose primary business is the manufacturing and selling of automobiles.

2. I am considered to be an expert in the field of mold or die production. I have a degree in Machine Engineering from Meiji University in Japan.

3. I have read the above-identified application assigned to Honda Motor Co., Ltd., which is based on Japanese application No.2002-316632, and I am familiar with disclosure of the above-identified application.

4. I am familiar with the subject matter being claimed in the above-identified application, i.e., a steel die for use in casting metal workpieces and a surface treatment method of such steel die for use in casting metal workpieces, including the claims 6,10,14 and 16-22 currently in the application.

5. I am also familiar with steel dies for use in casting metal workpieces and surface treatment methods for such steel dies which were known / conventional prior to the time that my co-inventors and I invented the subject matter claimed in the above-identified application, including the surface treatment method(s) for a casting die disclosed in Japanese Patent Publication 2002-060845 (hereinafter JP '845).

6. In the field of surface treatment, research is conducted to improve the useful life of metal products such as casting dies, and shows that shot peening prolongs the useful life. Therefore, the shot peening is widely used as surface

treatment for prolonging the service life of metal products. "Shot peening" is a cold working process in which small spherical media called shot bombard the surface of a part. During the shot peening process, each piece of shot that strikes the material acts as a tiny peening hammer, imparting to the surface a small indentation or dimple. To create the dimple, the surface of the material must yield in tension. Below the surface, the material tries to restore its original shape, thereby producing below the dimple, a hemisphere of cold-worked material highly stressed in compression. Because the overlapping dimples from shot peening create a uniform layer of compressive stress at metal surfaces, shot peening provides considerable increases in part life.

7. Conventionally, a shot peening treatment is performed to an object or a test piece placed in a cavity of a shot peening apparatus, and the shot are bombarded against the entire surface of the object at a specific shot pressure for a predetermined time period. That is, in a conventional shot peening treatment, if the shot peening time is set to 60 seconds, shot balls /particles are shot against the entire surface of the object for the entire period of 60 seconds.

8. At paragraph [0025] of JP '845, a method is discussed involving two shot peening operations each lasting for a time of 60 seconds relative to a test piece 1. I, as a person skilled in the art, understand this to mean that the test piece 1 is placed in the cavity of a shot peening apparatus and the shot balls /particles are shot against the entire surface of the test piece for the entire period of 60 seconds in each of the shot peening operations. That is consistent with conventional practice.

9. In the present invention, because the object is a casting die which is rather large in size, my co-inventors and I were unable to secure a shot peening apparatus that was large enough to accommodate the casting die therein. Therefore, when experimentally practicing the invention, we improvised by using a small, manually-operable shot peening nozzle for treating different portions of the casting die in sequential operations, i.e., the balls were shot from the nozzle toward one part of the casting die for the predetermined time of 5-10 seconds, then balls are shot from the nozzle toward another portion of the casting die for 5-10 seconds, and this procedure was repeated until all portions of the casting die were substantially uniformly treated for 5-10 seconds.

10. In the actual, experimental procedures conducted by my co-inventors and I, the size of the treatment portion was $5cm^2$, and this is reflected by the discussion at paragraphs [0047] – [0052] of the publication of the above-identified application, as well as in the language of claims 21-22 when these claims were originally introduced in Amendment-D, i.e., "5-10 seconds/$5cm^2$". This language that we used does not mean that any given shot peening time is merely divided by the surface area to be treated. Instead, the shot peening treatment time for the entire surface being treated is uniformly

within the specified range of 5-10 seconds according to the present invention, whereas the language "/5 cm^2" merely reflects the particular, unusual conditions which my co-inventors and I used for treating the large sized casting die because we did not have a treatment apparatus which could hold/enclose the die such that the die's entire surface could be concurrently subjected to the shot peening treatment for 5-10 seconds.

11. With respect to the invention defined in independent claims 6 and 17 of the above-identified application, such invention involves: a first (course) shot peening treatment which is substantially uniformly applied to the entire cavity surface of a casting die for a time period ranging from 5 seconds to 10 seconds, so that the maximum height of roughness of the casting dies is not more than 16 mm, and a compressive residual stress of the casting die is 1000MPa or larger after such first shot peening treatment; then a sulphonitriding treatment is applied to the cavity surface of the die; and then a second (finishing) shot peening treatment is substantially uniformly applied to the entire cavity surface for a time period ranging from 5 seconds to 10 seconds, so that the maximum height of roughness of the cavity surface is not more than 8 um, and the compressive residual stress is larger than 1200 MPa after the second shot peening treatment.

12. The invention defined in claims 6 an 17 of the above-identified application differs significantly from conventional techniques that existed at the time my co-inventors and I made this invention particularly in relation to use of multiple shot peening treatments, the length or duration of the shot peeing treatments, the surface roughness of the cavity surface of the die after the two shot peening treatments, and the final compressive residual stress larger than 1200 MPa, e.g., the duration of the treatments is only 5-10 seconds, which is much shorter than the treatment periods in the conventional techniques, and the surface roughness of 16 μm and 8 μm is much less that that in the conventional techniques, including the technique(s) disclosed in JP '845.

13. In the conventional techniques, after a shot peening treatment, a small surface roughness of not more than 8 um would not be obtained. Rather, at the time my co-inventors and I made this invention, it was conventionally recognized that a surface roughness significantly larger than 8 μm has a conventionally recognized benefit. Particularly, in a casting die, a molten metal flowing into the die has an oxide coating on its surface, and when the die has a surface roughness of approximately 50 μm, the oxide coating will be caught and broken by the die surface, so that a clean molten metal will flow in the die improving the heat conduction speed between the molten metal and the die. For a casting die, a surface roughness (maximum height) of approximately 50 μm is enough to obtain a better surface quality for the cast article. Therefore, at the time my co-inventors and I made the present invention, those of ordinary skill in the art would try to make the surface roughness

approximately 50 um after the shot peening treatment, and would not try to obtain a surface roughness of a smaller value.

14. In spite of conventional wisdom, my co-inventors and I found that the die cavity surface should be maintained as smooth as possible to increase a heat transfer rate between the cast metal and the die surface and also to obtain a better quality for the cast article. For this purpose, we intentionally made the surface roughness not more than 8 um by setting the shot peening time for a period in a range of 5 to 10 seconds in each of the first and second shot peening treatments. The shot peening treatment for such a reduced duration is contrary to the conventional techniques that existed at the time my co-inventors and I made this invention, including the technique(s) disclosed in JP'845.

15. Tests were conducted in comparison of the subject matter presently claimed in the above –identified application and the prior art, specifically Japanese Publication 2002-060845 (hereinafter JP '845), including shot peening treatments of 60 seconds as disclosed by JP '845.

16. Experiments were conducted under the conditions in accordance with claims 6 and 17 of the above-identified patent application (TEST A), and the conditions discloses in JP 845 (TEST B), with respect to the cavity surface of the casting die made of a steel material. Specifcally, in TESTS A and B, Carborundum ™ (ceramic particles) with a diameter of 220 mesh (average particle size of 50 um) were used in the first shot peening, and glass beads with a diameter of 220 mesh (average particle size of 50 um) were used in the second shot peening. In TEST A, a steady stream of Carborundum ™ was projected for 10 seconds by injection pressure of 0.49 MPa in the first shot peening, and a steady stream of the glass beads was projected for 10 seconds by injection pressure of 0.49 MPa in the second shot peening. The resultant surface roughness of the cavity surface evaluated after the second shot peening was 8 um. In TEST B, a steady stream of Carborundum ™ was projected for 60 seconds by injection pressure of 0.3 MPa in the first shot peening, and a steady stream of the glass beads was projected for 60 seconds by injection pressure of 0.4 MPa in the second shot peening, as disclosed in JP 845. The resultant surface roughness of the cavity surface evaluated after the second shot peening was 61 um. The conditions and the results are shown in the table of the declaration filed with Amendment G on 28 January 2009.

TEST	First shot peening				Second shot peening				Ry (μm)
	Particle	Particle Size	Injection pressure (MPa)	Shot time (s)	Particle	Particle Size	Injection pressure (MPa)	Shot time (s)	
A	Carborundum™ (ceramic)	220 mesh	0.49	10	Glass	220 mesh	0.49	10	8
B	Carborundum™ (ceramic)	220 mesh	0.3	60	Glass	220 mesh	0.4	60	61

The test results demonstrate that the surface roughness Ry (maximum height) varies as the shot time is extended from 10 seconds to 60 seconds, and largely exceeds 8 um up to 61 um. These results were expected by my co-inventors and I given the conventional nature of the process disclosed in JP '845, which is contrary to our claimed invention.

17. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: 09-JUN-2009

Hiroaki Koyama
Inventor signature